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RICHARD KADULSKI
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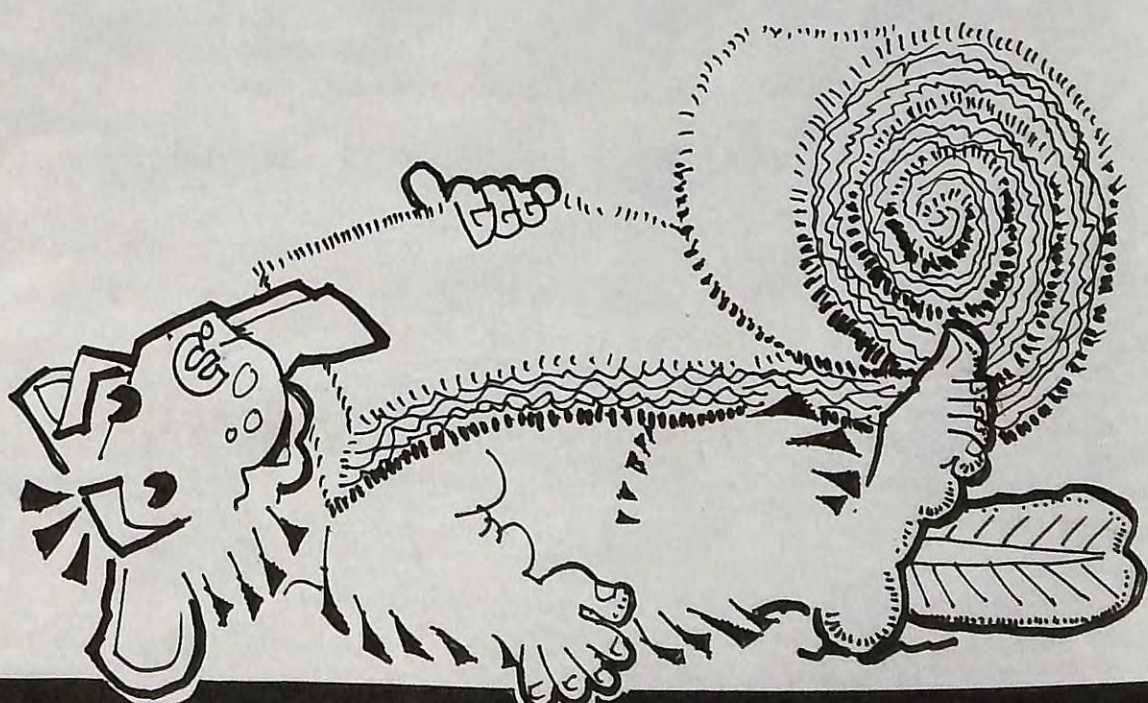
Insulation



From The Editor . . .

Our world view is shaped by our experiences. Like others here, I am an immigrant to the West Coast who has also had the good fortune to live in and visit others parts of Canada. I am aware of and have experienced the climatic extremes for which Canada is noted. However, I realize that I'm still influenced by the relatively balmy climate conditions we experience here in British Columbia.

Residents here quickly become locals and forget their past. They fall in love with the setting and quickly go native. After all, when you see palm trees in the parks (there are some species that grow on the West Coast), the exotic flora has the effect of lulling one into the belief that we don't really need to deal with energy efficiency. This makes promoting energy conservation a seemingly difficult task.

Home energy efficiency upgrades can be a tough sell here. Builders remind me that homebuyers aren't really interested in such mundane things as better windows, more insulation, or a more efficient mechanical system. Those things are OK for Calgary or Winnipeg, where it gets cold, but not for the balmy West Coast. Buyers here, I am constantly informed, are more interested in granite countertops and marble or hardwood floors. They never ask about heating systems or better windows. Of course, builders do not offer upgrade packages either. At most the options offered are for floors, countertops and the colour of wall paint.

I suspect that most buyers assume that they're getting the best technical components for energy efficient homes, so why do they need to ask for them? After all, haven't we been telling them about how wonderful the product we produce is?

While making a presentation in the Okanagan valley recently I was surprised when a builder said that he was at the session because he was feeling pressure from purchasers who were asking about energy efficiency options in his new homes. They wanted energy efficient homes. The buyers understood that energy prices are not coming down; that there are options that can be chosen to improve home performance. They understand that performance improvements that are built in will provide returns for many years into the future.

On the West Coast we may live in a bubble, isolated from the cold Canadian winters, but we still need to heat our homes. The energy bill of the average home in the Vancouver area, in dollar terms, is not that much lower than in any other part of Canada – even though it should be.

I was involved with one energy efficient home project a few years ago which brought home to me the fact that we can have houses that do not require any heating system. The owner, who is the second owner, thought there might have been a problem with the mechanical system. It was discovered that the first owner left in a huff and in the process tore out some wiring, including heating system control wiring. It turned out that the house had been operating without a functioning heating system, since the discovery was only made after the current owner had lived in the house for a full year. The house was well insulated, had high performance windows, and took maximum advantage of solar gains, which was enough to keep the home comfortable.

Every new house could be that well built. The house might still need a bit of supplementary energy, but it would be a much smaller portion than the average new house today. If we are going to tackle the serious climate change issue confronting us, and wean ourselves off fossil fuels, we need to get serious and take action now.

If we are committed to leaving a better world for our children, we need to remember that small individual actions will grow cumulatively and have a big impact on the country and ultimately on the earth.

Richard Kadulski,
Editor

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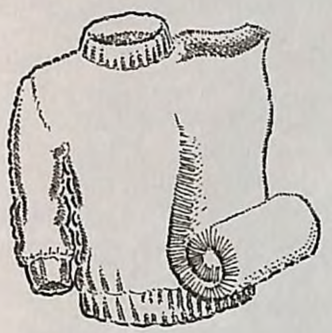


Insulation: How much is enough?

Insulation is an important component of buildings to keep them warm and comfortable in winter and cool in summer heat. Many types of material can be used as insulation, but the prime requirement is that the material resists heat flow.

How much insulation is enough? Product suppliers stress the positive features of their product and downplay any negatives. Because of the variation in product pricing, some suppliers downplay reasonable insulation levels and use arguments that may be misleading for purchasers. In the process they often create confusion, making it difficult for builders, designers or owners to make a decision

Some suppliers rationalize using less insulation because of the diminishing return from each increased increment of it. It is a fact that the impact of more insulation decreases with each additional increment. If you start with an uninsulated building and add one inch of insulation, you get big savings. As you keep adding insulation, you get fewer savings from each additional layer. However, adding insulation always reduces energy consumption. The debate is engaged when this turns to what may be an optimum level of insulation. Decisions are usually based on insulation levels that are cost effective. The challenge is to use appropriate energy costs.

Decisions on insulation levels are often based on an economic analysis or on perceived paybacks. There was a time, not that long ago, when even modest levels of insulation and multiple pane windows were considered uneconomical. That is why so many older buildings are woefully under insulated; because analyses were done showing why adding insulation was not economical! However, it is important to recognize that most economists' long-term forecasts about energy costs done even one year ago are obsolete as a result of the sharp increase in energy prices in the past few months.

In today's world there is one certainty – current high energy prices are here to stay. We are at peak production for petroleum-based fuels. The need to reduce greenhouse gas production (using less energy to condition buildings) means that the pressure to reduce energy use in buildings is also here to stay. An important part of this is to build in passive energy conservation, which effectively means higher performance construction with higher insulation levels.

Spray foam suppliers focus on the air-sealing value of their products, which although very important, leaves the impression that if you air seal the house with a thin continuous layer of foamed insulation, you will not need as much insulation.

Reducing the air leakage across the envelope will reduce the energy loss, but the impact of air sealing is going to be influenced by what areas of the house are air-sealed. Although we want to air seal the entire envelope, air leakage in the upper part of the house, through ceiling penetrations, can have serious consequences not only because of heat loss (driven by the buoyancy of warm air) but also on the building's durability. Warm air leaving the house is the driving force in moving significant quantities of moisture.

The amount of insulation to be used will depend on a number of factors, including the types of insulation products available in a given location, the house design and structure, and how

What is the impact of air sealing on energy consumption?

A quick HOT-2000 review of a basic production house design shows what impact air sealing may have on energy consumption. Simulations were done for a house in Vancouver, Calgary, and Toronto. The base case was a construction package that essentially met the R-2000 energy performance target, except for the air sealing. The base case assumed the house had 4.55 air changes at 50 Pascals, and the upgraded air sealing was done to R-2000 standards.

Heat loss by air leakage changed from 18% to 10% of total in Vancouver, and in the Calgary and Toronto climate from about 26% to 15% of total. In terms of reduced energy consumption, energy use would drop by 10% in Vancouver (6.1 GJ), 15.5% in Calgary (15.1 GJ), and 13% in Toronto (10.1 GJ).

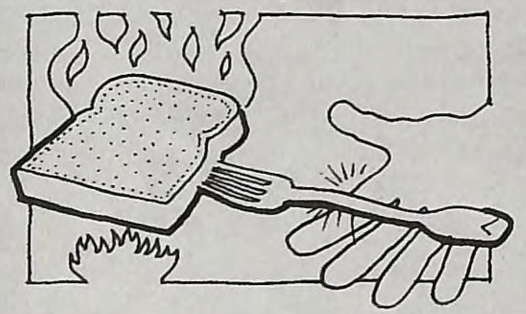
With natural gas prices hovering around $12 per GJ, air sealing does represent a significant savings for the homeowner.

In all cases, the heat loss through the walls was about 30% of the total, through the ceiling 5%, through windows and doors 30%, and the basement about 20%, so walls, windows and basement still represent significant sources of energy loss and should be well insulated.

well a specific product can be integrated into the fabric of the house. If there is one thing we know today, it is that making decisions only on the basis of today's energy and material costs is questionable. From a long-term point of view, insulation levels should be as high as is practical. It is always cheaper to install more insulation at the time the building is being built, than it is to retrofit a building at a later time.

The Mechanics of Heat Flow

Measuring heat flow and the resistance to heat flow is complex because heat flows via three mechanisms: by conduction, convection, and radiation. All three mechanisms can also occur simultaneously.



Conduction

Conduction occurs when the molecules within a solid object are excited by a heat source applied to one part of the object. The molecules pass the energy from one to the other. An example of conduction is the way heat moves from an electric stove when a pot is put on it and the stove is turned on.

Conduction is the major heat flow mechanism across the building envelope. To reduce conduction most insulation products contain many tiny air pockets, which are small enough that they reduce the possibility of convection air flows.

Manufacturers of reflective insulation have long claimed miraculous value for their products. Aluminum foil does offer reasonable insulating value in some applications when installed correctly. However, the radiant component of heat loss in the temperature range seen in houses in most cases is a very small part of total heat loss.

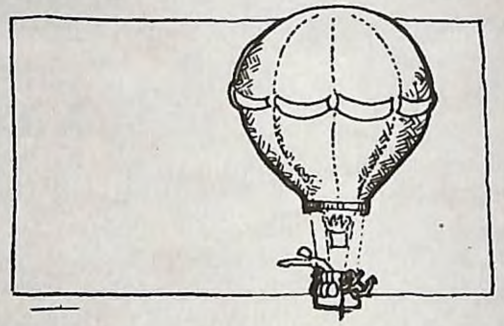
In some cases test results are extrapolated from a test for a specific application under one set of conditions with the implication that this will work the same way across the total envelope of the house in all climate conditions. This, of course, is not correct.

For example, a floor over an uninsulated crawl space that is insulated with only a foil sheet on the bottom side of the floor joists can provide fairly effective insulation. This is because of the nature of heat flows. The reflective foil, which has a low emissivity, does not emit much heat. Being exposed to an air space, on the underside of the floor the reflective property will work.

However, if the foil is applied to the wall, the wall must be strapped to create an air-tight space; otherwise the reflective properties of the foil will not be effective. If the wall is strapped vertically, the vertical channels between the interior finish and the foil offer the opportunity for convective loops to be generated, especially if the outside of the foil is cold, so mass insulation must be installed on the exterior.

Convection

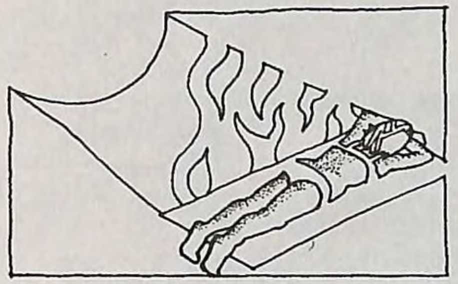
Heat transfer by convection occurs in fluids such water or air. As the fluid is warmed it becomes less dense and, as it rises, it is displaced by cooler fluid surrounding it. This is how a baseboard heater heats up the air in a room as the air is slowly circulated around it. Convection currents in the air space between two panes of glass means that the cool air in the cavity will settle near the bottom of the window. That explains why condensation usually starts at the bottom of windows in winter. Similarly, in uninsulated or poorly insulated walls, the air in the dead space sets up thermal currents – as the warm interior warms, the air rises and is replaced by falling cool air against the exterior side.



Radiation

Radiation is heat transfer through the space between a warm body and a cooler object. Radiant heat transfer is blocked by opaque materials between the source and the receiving body. For example, the sun's heat energy reaches us through the vacuum of space to heat the earth. We are warm in the direct sunshine, but if a cloud crosses over or we move into the shade of a tree or building, it becomes significantly cooler.

The heat given off by a wood stove is transferred by radiant energy. The discomfort we feel in front of a large picture window on a cold winter night is caused by the radiant heat loss



from one body to the cold glass by radiant heat flow. The amount of radiant energy emitted by a material depends on the material's temperature.

All three heat transfer mechanisms are at work at any given time. In a house, most heat is lost through the building envelope by conduction and through the loss of heated air due to air leakage and ventilation – a portion of which is influenced by convention currents in the house. Most construction and insulation materials are opaque to radiant heat flow. Radiant heat flows across the building envelope primarily occur through transparent surfaces – that is why windows are good solar collectors when in the sun and thermal holes when out of the sun, on the north side, or at night. New window coatings are designed to address some of these heat transfer issues.

Heat transfer by conduction through the building envelope is dependent on the surface area, the temperature difference and the thermal resistance. As a formula, it is expressed as:

$$Q = \frac{A \times dT}{R}$$

Where:
Q = heat transfer
A = area of the element
dT = temperature difference between inside and outside
R = thermal resistance of the material or assembly

R-value is a measure of the ability of a material to resist heat flow. R-values are determined by a laboratory test under defined conditions.

Actual heat loss will depend on how well the insulation has been installed, the air leakage through the insulation and its moisture content. The more gaps and cavities there are in the space, the lower the insulation value. That is why building designers are interested not only in the R-value of the insulation material itself, but also in the construction of the whole assembly. As well, water is an excellent conductor of heat, so any moisture trapped within insulation can reduce its insulating properties.

The thermal resistance of insulation materials varies depending on the cell structure, the gas contained in the insulation and the moisture content. Generally, the smaller the cells, the more effective the insulation material. Some foamed insulation products are blown with gases that may be more effective than air at reducing heat transfer. However, these gases may also dissipate over time, reducing the insulating properties, which is why we are interested in aged R-values. ☼

Insulation Products

A variety of products is used for insulation. Each insulation type has its unique properties, and will do a good job when used appropriately.

Batt type insulation is the most commonly used product in residential construction. It is usually made from glass or mineral fibres. Batts are used indoors and must be protected from moisture. Recently, new materials used for batts include cotton and wool.

Loose fill insulation can be a variety of products that are blown into place. Typically, these are chopped glass fibres, mineral wool and cellulose. Other loose fill products are vermiculite (which is an expanded mineral) and pearlite. Spray cellulose insulation is available in a variety of formulations. Some are sprayed with a small of quantity binder to glue the fibres together.

A variety of rigid foam products is available. Their rigidity and R-value depends on the density and nature of the material.

Extruded polystyrene (XPS) is manufactured by extruding a hot mass of polystyrene using a refrigerant gas which expands at atmospheric pressure. This typically has an R-value of 5 per inch thickness.

Expanded polystyrene (EPS) is made by expanding polystyrene beads in a mould. The R-value depends on the product density.

Polyisocyanurates are rigid boards made with a chemical reaction. These have a higher R-value but also lose some insulating value because the blowing agent gases escape over time.

Spray-in-place foam insulation products combine two ingredients in a chemical reaction at the time of installation. These products require

qualified applicators. Two types of spray foam are commonly used. A closed-cell polyurethane, which is airtight and has a low permeability with an R-value of about 6 per inch thickness. The second is an open cell foam which has an R-value of about 3.5 per inch thickness.

Low density, open-cell spray foam insulation products (such as Icynene or Demilec) are airtight but vapour permeable, so they require vapour diffusion retarders.

Natural products such as straw bales are also used as insulation. However, the low insulation level per unit thickness (an R-value of about 2 per inch thickness) means that they require special design considerations, as walls will be thick – typically the thickness of a bale of hay, which is about 2 feet. Two-foot-thick walls are not likely to be considered for compact urban sites. ☼

Reflective Insulation

Reflective insulations offer an alternative to conventional bulk materials used to reduce heating and cooling loads in buildings. However, they require one or more enclosed air spaces.

When a low-emittance surface is positioned perpendicular to the direction of heat flow it can reduce the thermal radiation across the adjacent air space and the R-values can be measured or calculated.

The reflectance of a surface on an opaque material is the fraction of incoming thermal radiation that is reflected and not absorbed by the surface.

Emittance is a measurement of how efficiently a surface gives off heat in the form of thermal radiation. Thermal emittance is the ratio of radiant energy leaving a surface at a given temperature to that of the radiant energy from a "black body" at the same temperature. A perfect black body gives off 100% of the possible radiation at a given temperature.

Reflectance and emittance are expressed in numbers between 0 and 1. In the case of opaque materials, the reflectance plus emittance always equals 1.

Aluminum foils or metallized films have an emittance of about 0.03 to 0.1. The corresponding reflectances are 0.97 to 0.9. A good reflector must remain clean and dust free. Accumulation of dirt and dust lowers the foils' effectiveness.

The R-value of a reflective insulation system depends on the distance across the air space in the direction of heat flow, the temperature difference across the air space, the emittance of the surfaces facing the enclosed air space, the average temperature of the air space, and the direction of heat flow.

The direction of heat flow is important because natural convection can occur in the enclosed air space. The amount of the convective heat transfer will depend on the direction of heat flow because it is the result of differences in air density (buoyancy) that are caused by differences in temperature. Heat transfer by convection is less significant for heat flow down than for heat flow up. As a result the R-values for reflective insulations are greatest for heat flow down and least for heat flow up when all other factors are equal.

This is why they are especially effective in roof spaces, on the underside of roof rafters, and in hot climate conditions when cooling is a consideration. ☼

The R-value for a single reflective air space at an average temperature of 75°F, with a temperature difference of 30°F:

- ☞ for an air space of 0.75" the R-value for heat flow up is 1.73, for heat flow down is 3.55
- ☞ for an air space of 1.5" the R-value for heat flow up is 1.90, for heat flow down is 6.05

From: *Reflective Insulation for Residential and Commercial Applications* by David W Yarbrough, R&D Services Inc. on the Reflective Insulation Manufacturers' Association web site: www.rima.net

Reflective Insulation Materials Used Under Concrete Slabs

A heated basement floor slab requires insulation underneath it to keep the heat in. A common detail is 3 to 4 inch thick concrete floor slab on 4 to 6 inches of gravel, with in-floor radiant heating. In BC, the Building Code requires a minimum of R-12 under the slab.

Some suppliers are promoting the use of reflective insulation materials. However, these floor systems do not incorporate an air space adjacent to the aluminum foil surface(s) of the reflective insulation material, so the reflective component of the insulation cannot work.

The Reflective Insulation Manufacturers Association (RIMA) set out to clarify the expected performance of reflective insulation materials used in under slab applications.

Calculations were done based on steady state conditions for a heated slab with an assumed ground temperature of 55 °F and temperature of the water in the heating pipes at 125 °F. When a reflective insulation material (R-1.10) is located between the concrete and the gravel, the system R-value is R-1.95 which results in a heat loss reduction of 56% when compared to the same concrete floor system without insulation. This is the source of some of the extravagant claims for foil insulation products. However, the total R-value for the floor system is still less than 2.

It is important to note that the calculation used to generate the example described above does not include any additional thermal benefit resulting from the aluminum surface(s) of the reflective insulation material, since there is no air space under the slab. In other words, the reflective insulation material is performing similar to a non-reflective insulation material.

ASTM C 168, ASTM C 727, and ASTM C 1224 define a reflective insulation as a thermal insulation consisting of one or more surfaces having an emittance of 0.1 or less, which equates to a reflectance of 0.9. ☼

Heat Loss in Pictures

Infra-red cameras can be a good diagnostic tool to identify locations of heat loss, poorly installed or missing insulation, thermal bridging through framing and even hidden moisture locations. We pointed an infra-red camera at two randomly selected houses in North Vancouver and observed where heat is leaking.

A common heat loss area is the foundation. Continuous foundation insulation is often overlooked, yet it is an important area for heat loss.

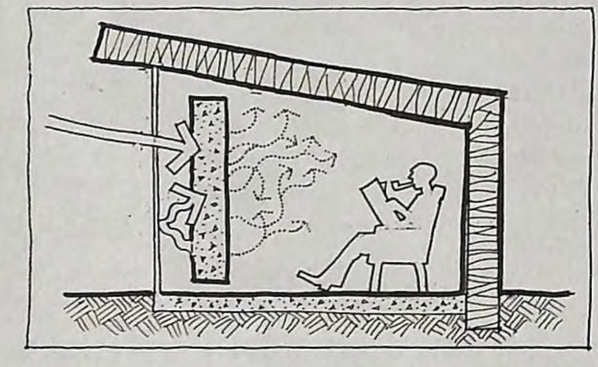
Older sixty year old house. Uninsulated basement and poorly insulated and sealed ceiling are major locations of heat loss, as are the single glazed windows.

House built about 5 years ago. It has a slab-on-grade, with in-floor radiant heating. The slab is insulated with rigid insulation under the slab, as required by the BC Building Code. The white areas show maximum heat loss. Heat loss occurs at the ceiling, probably the result of air leakage. The second area of considerable heat loss is at the grade line, as the slab edge seldom is insulated.

You Asked Us:

Why we don't see many Trombe walls in our climate?

Trombe walls, named after Felix Trombe, a French solar pioneer, are south-facing heavy mass walls located inside just behind south-facing windows. The mass walls are intended to store solar heat collected during the day to provide heat at night. Trombe popularized the concept in the 1960s, although it was first patented in the US in 1881. The south-facing mass structure is a concept that has been well understood for centuries by traditional builders in many parts of the world.



Trombe's early examples were built in the Pyrenees in southern France, a climate with some resemblance to that of the Southwestern United States, such as in Arizona and New Mexico. These are climates with intense sunshine, relatively uniform hours of daylight, with hot days and cold nights. This means there is fairly constant solar intensity and a need for daytime shade to reduce overheating and nighttime heating.

The principle of the Trombe wall is simple. South- facing windows are placed in front of a mass wall. The mass wall may also incorporate vents at top and bottom to allow convection air currents to rise up the wall and move heat into the house when heat is needed during the day. Dampers prevent nighttime reversal of cold air. At night, when heat is needed, the back of the mass wall itself acts as a radiant surface for the interior.

In the 1970s efforts to improve performance included the design and installation of insulating curtains to roll down in front of the mass wall to reduce the heat loss from the mass wall to the outside.

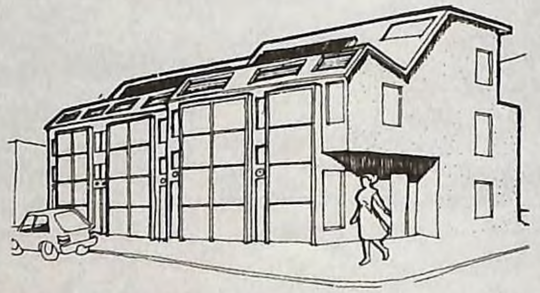
Many buildings and houses with Trombe walls were built in North America in the later 1970s and 1980s during the flush of enthusiasm for solar applications and energy conservation as a result of the oil shock of the 1970s. In Canada, a townhouse project was built in Vancouver, and Keith Funk, a Saskatoon builder, incorporated Trombe walls into the design of modest passive solar energy homes on the prairies. The monitoring of these and other projects throughout the US showed the importance of designing buildings to match the climate of the location.

It became evident that in northern latitudes, with the short winter days and low sun angles and (especially on the prairies) the extremely cold climate, the amount of energy available from the sun was not enough to properly charge a thermal mass. It was found that the thermal mass must be carefully sized for the climate and available solar resource.

In addition, in cold climates, large windows should have good movable insulation to protect against nighttime heat loss; otherwise some heat from the mass wall will be lost outward. Adding movable insulation, a mechanical element subject to maintenance and occupant operation, is asking for trouble because it will not be maintained over time. This is one observation that has been made in the case of the Vancouver townhouses.

There is also a design constraint imposed by the need to have south-facing windows with a mass element behind them, thus limiting the views, light, and direct sunlight into the home.

So while the Trombe wall works well in some regions, we have learned that it is not the most appropriate approach for Canadian climates. Good energy conservation strategies, improvements in window technology, along with optimizing a home's passive solar design go a long way to addressing energy needs without the design constraints provided by a south-facing mass wall. ☼



Vancouver Passive solar townhouse project

Technical Research Committee News

Indoor Air Quality Assessment Tool

Many building materials and furnishings emit chemicals called volatile organic compounds (VOCs), which can adversely affect the health of building occupants. VOCs are present in varying degrees in all building products. They are also emitted from many consumer products such as cleaning solvents and aerosols.

How people react to VOCs varies from person to person, but we do know that there can be reactions. As awareness of VOCs has increased in recent decades, there were two problems facing designers and builders. The first was the lack of standards for consistently quantifying the nature and concentrations of these compounds, of which there are hundreds. The second was the difficulty in linking the compounds to health effects. Although it has been known that VOCs could adversely affect air quality, there has been little guidance to help designers select materials that would reduce harmful emissions.

A consortium organized by the NRC Institute for Research in Construction in the late 1990s sought to address this lack of data. The researchers started by identifying 90 VOCs emitted from building materials, about half of which are known to be potentially harmful to human health. More research is needed to determine safe exposure levels for each type of VOC, taking into account the variations in human sensitivity. In the meantime, it is generally accepted that it is good practice to keep VOC emissions in buildings as low as possible.

The research team developed test standards so that emissions could be measured consistently. The new test protocols were used to test the composition of emissions from commonly used building materials. This information became the starting point for a database, which has become a part of a software package called MEDB-IAQ. The database now contains more than 2,600 combinations of materials and chemicals.

MEDB-IAQ software is a tool that can predict the chemical concentrations in a room for given materials and ventilation conditions. For instance, it can be used to determine whether the designer's choice of materials and ventilation strategies can meet a specific air quality guideline such as that of the World Health Organization. It can also be used to find out how long it will take for the emission concentration to fall below the guideline.

The software should be ready for downloading from the IRC web site soon. It will not be something that everyone will need to rush out and get a copy of, but it will be another tool for those who need to address specific issues on a project.

R-value Labelling

The US Federal Trade Commission has explicitly defined how home insulation product R-values can be advertised (Rule for Labelling and Advertising of Home Insulation - "R-value Rule"). The FTC requires manufacturers and suppliers to use specific test procedures for measuring the R-value of reflective insulations with single and multiple sheets. It also contains requirements for measuring and labelling insulation materials with foil facing.

Manufacturers must provide the R-value information for their insulation on labels, in fact sheets, and in advertising.

The FTC has noted that some suppliers have marketed foil-faced bubble-pack or foam products for use in concrete floor systems claiming that such products provide a high R-value (R-5 to 10), largely on account of their reflective qualities. Such claims are misleading and could harm the ability of builders and other consumers to make appropriate insulation choices. They note that "It is well accepted that reflective insulations must have an air space adjacent to the reflective material to be effective. Such air spaces are unlikely to exist under concrete slabs. We are unaware of data to suggest that the reflective qualities of these products will yield any significant benefits when they are installed under slabs. Foil-faced material installed in such a way is unlikely to function as a reflective insulation".

FTC guidelines published in 1980 state that a reflective product installed without the benefit of an adjacent airspace will have what can be termed its "material R-value." This is simply the

Canadian Home Builders' Association

The Technical Research Committee (TRC) is the industry's forum for the exchange of information on research and development in the housing sector.

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R-value of the mass insulation material, as tested in accordance with standard procedures testing. If the same foil-faced product is installed with an adjacent airspace, it may have what is called a "system R-value" which includes the benefits of the material's reflective qualities plus its mass insulation properties.

FTC's R-value Rule recognizes that mass insulation materials with reflective facings can have two different R-values, depending on the manner of installation. Insulation materials with foil facings must first be tested for the R-value of the material alone (excluding any airspaces). Then, a second test can be done to determine the system R-value by adding the tested R-value of the material plus the R-value of the airspace.

Because the system R-value of these materials will depend on a number of factors, such as the thickness and configuration of the air space and *the direction of the heat flow*, the manufacturer must state clearly and conspicuously the conditions under which the stated system R-value can be attained in connection with any system R-value claim. A simple description of the system R-value, such as "system R-value of 6.2" does not comply with the Rule. Similarly, the simple notation that the system R-value is "as per ASTM C518" is not enough. Manufacturers must specifically disclose the thickness of the airspace, the specific installation conditions and the configuration necessary to obtain the system R-value.

Suppliers or manufacturers who violate the FTC Rule are subject to penalties of up to $11,000 per violation. ☼

A letter explaining the FTC requirements is posted on the Reflective Insulation Manufacturers Association web site: www.rima.net

Details of the FTC R-value Rule are available on the FTC web site: www.ftc.gov/energy

Field Performance of Integrated Mechanical Systems

eKOCOMFORT™ Field Assessment Program
Prepared for CMHC National Office by Peter Edwards Co.

Integrated mechanical systems that provide heating, ventilation and space heating in a single system are becoming increasingly common. A number of manufacturers are now putting packaged systems on the market.

Because of the need to improve energy efficiency and reduce greenhouse gas emissions in the residential sector, the federal government has been supporting the development and deployment of new technologies. The eKOCOMFORT™ name and trademark was developed by the manufacturers for product branding, licensing, and marketing to identify this new class of HVAC products. (Solplan Review No. 124, (Sept. 2005).

Do these products really work as intended?

CMHC and NRCan carried out a joint study to evaluate the performance of early production samples of these integrated systems developed by several independent Canadian manufacturers. The performance assessment of the units once installed was carried out over two years in homes in different regions of the country to assist each manufacturer in refining their products.

Although the intent was to evaluate system installation in real-world applications, most of the installations were performed at "friendly" sites, and in most cases the "installer" was also the manufacturer. While installing the first production products in friendly sites makes a great deal of sense, in order that any problems with the systems could be quickly and quietly resolved, the number of "friendly installations" reduced the effectiveness of the survey.

Despite these shortcomings, the study produced valuable findings that are applicable not only for the manufacturers, but also provide lessons for designers, installers and builders. Installers who do site integration of disparate components will also benefit.

Key findings are:

Surveys of homeowners indicate that the users are happy with the systems, and that the installed systems are working with no major problems. They provide the required output for space heating and water heating. The installers indicated they would install the equipment (and similar generic equipment) again in other customers' homes.

Homeowners generally believed they were benefiting from state-of-the-art equipment. Almost all believed that the indoor air quality of their homes had improved because of the integrated ventilation systems. However, many did not know how to adjust the ventilation rates of their system.

The way that heating equipment system loads are normally sized needs to be reexamined because adequate credit is not given for internal gains associated with appliances and other internal gains. Overall the integrated systems were found to operate at average daily system loads that amounted to between 10 and 29 percent of their design capacities.

Current practice is to size a system to provide at least 100% of the design-heating load (plus an extra allowance) regardless of whether any supplemental heating appliance such as a gas fireplace or a woodstove is available. If the sizing practice for a central system were revised to reduce or eliminate the contingency factor and to take other heat sources into account, the central system could be downsized, and the overall operating efficiency of the system would increase.

The existing furnace and boiler AFUE (annual fuel utilization efficiency) ratings do not to reflect the efficiency losses under part load operation. The laboratory test procedures for integrated (and other) HVAC systems need to place greater emphasis in part-load system performance. A new CSA P.10 standard that is being developed for Integrated Mechanical Systems will include a part load performance testing section.

Combination Space & Water Heating Systems

Combination space and water heater systems ("combos") were first introduced into Canada about twenty years ago. Early combo systems were available from a small number of manufacturers as packaged systems or (more often) as field-assembled systems where the installer assembled and packaged an air handler with a water heater or tank, circulating pump and related controls. At the time they were promoted as a way to reduce costs and increase the overall energy utilization and potentially increase the efficiency of space and domestic water heating systems.

Problems with combo systems were quickly noted, mostly relating to the system capacities, thermal comfort, and service warranties. Water heaters were often inadequate and distribution systems were not properly sized. As a result, the industry tried to develop design guidelines. One of the first widely distributed guideline documents that covered the use of combo systems was developed in British Columbia with support from BC Gas in 1994.

These guidelines became the core of current design standards for combination mechanical systems.

Site audits revealed problems at some installations. These include:

- Controls to activate the high-speed ventilation mode had not been installed.
- The ventilation systems were not operational because dampers had not been properly connected.
- In most locations, the ventilation airflows were not balanced within the manufacturers' specifications. This may have been the result of the manufacturers' unfamiliarity with the efficient variable-speed programmable blower motors that they had incorporated in their products. All of the integrated systems used a single blower motor to provide air circulation and at least one of the ventilation airflow.
- Differences in the duct resistance between the laboratory and the field affected the flows as well as the balance between the circulation flow and ventilation flow.
- Two of the integrated products did not operate correctly using a commonly available HVAC thermostat until the system control boards were upgraded. This problem had not been identified in the test laboratory.

Points To Consider When Laying Out a Heating System

The physical location of the system in the home and the duct layouts can affect the performance of a heating and ventilation system.

A central installation is desirable to optimize the distribution effectiveness of heating and ventilation ducts.

Although ventilation duct energy losses are not currently incorporated into the performance ratings for HRVs, long ventilation duct runs increase energy losses from the basement zone to both the supply air and exhaust air ducts. A location near an external wall that minimizes the length of "cold side" ventilation ductwork will improve the performance of the ventilation heat recovery system. While this is an issue for HRV installations, the ventilation duct lengths may be longer in integrated systems than for stand alone HRVs. Thus integrated systems may need to have higher levels of insulation applied to their ventilation ducts than conventional HRVs.

A location close to a side-wall may also simplify the combustion venting of the integrated system.

Did You Know?

Although the need for as well as the use of residential ventilation systems has not been as widely accepted in the US as it has been in Canada and Europe, US codes are increasingly recognizing that ventilation systems are needed as homes become more energy-efficient.

One indication of the emerging recognition of the need for ventilation in the US (and the success that the Canadian HRV suppliers have achieved) was the decision by US-based Broan Industries to purchase Venmar ventilation in 1995. Further industry consolidation occurred when Broan's owner, Nortek, acquired Nutone. As a result, a single company now controls most of the recognized ventilation brand names in North America.

Annual Fuel Utilization Efficiency (AFUE): A measurement of the performance of a furnace or boiler operating as a space heater. It is determined using a standard test procedure with the heater operating at maximum capacity and at steady-state conditions. The test conditions used for AFUE ratings are different from the way a typical operates. Many boiler-based systems are designed to cycle when operating in space-heating mode.

Energy Factor (EF): A measure of a water heater system's overall efficiency expressed as the ratio of the energy supplied for heating water to the total daily energy consumption of the water heater. It is based on a standard daily hot water load of 243 litres with a standard temperature rise of 42.8°C. An application rating is provided with the same daily hot water draw volume, but with the inlet water temperature lowered to produce a standard temperature rise of 50°C.

Letters to the Editor

Sir

I have been in the construction trade since the early 1960s. Over the years I have seen many changes. I have also been fortunate enough to work in BC, where I was very disappointed with the construction skills I saw.

In the mid 1980s I was in rural Ontario and became interested in the R2000 concept. I can honestly say it was well worth the investment, but trying to educate others was to no avail. Other contractors convinced their clients to build houses approaching the R2000 standard and got themselves into big difficulties. I have been in many houses where I could sense mould in the air. However, I can honestly say I have never once had any mould problems or air quality concerns.

I am convinced R2000 is the way to go, but because of the additional cost to build an R2000 house I have not been able to convince many people. Unfortunately, too many people don't understand the concept. I believe that even many local municipal authorities have not understood the concept.

I have also had the opportunity to travel the world and I am still proud of the way we construct buildings here in Canada.

Murray Hebblethwait
Dura-Built Enterprises

Sir,

I'd like to express my appreciation for work you have done. I've been able to make good use today of information from your Nov 2000 issue of Solplan Review (Ventilation in Existing Houses).

You have benefited many of us, so thanks Richard.

Hope all is well with you.

Roger Olson.

Thanks for the note. It's always nice to hear that our work is appreciated. Ed.

Sir,

Re: Air Tightness Testing (Solplan Review No. 125, November 2005)

I've read Solplan Review for years and always felt that it makes a positive contribution to the building industry. As a building scientist I was pleased to see your article on "Air Tightness Testing" in the November 2005 edition.

However, I should point out an error in your discussion of ACH50 in the section "What do Air test Numbers Mean". The statement: "Another way to Convert ACH at 50 Pa to "natural" air changes per hour is to multiply the airflow at 50 Pa by 60 minutes per hour and divide the product by the total heated building volume (including the basement) measured in cubic feet." is not correct.

In fact ACH at 50 Pa is equal to the CFM50 x 60 minutes divided by the conditioned building volume. Converting an ACH50 to an ACH natural is as you indicated elsewhere quite problematic, but using Persily's method of dividing by 20 is a reasonable first order approximation. Your "Another way" is not. It is the formula for calculating ACH50 given a CFM50 test result.

David Hales
Washington State University Energy Program
Spokane, WA

Thanks for the correction. Ed.

OOPS! Re: P2000 Insulation

In Solplan Review 125 (November 2005) issue we discussed foil faced insulation products, and made reference to P2000 insulation. We mentioned that the product is not listed with CCMC. It has been brought to our attention that this product has indeed been listed. There are two listings: 13180C (P2000 Silver Insulation) and 13202C (P2000 Bronze Insulation). Our apologies to the manufacturer.

We note, however, that these listing are for the product as Expanded Polystyrene Insulation Board, so the applicable properties are the same as for other EPS products. No additional credit is attributed to the foil facing. We assume that if strapping is applied over the foil-faced side, the insulation upgrade for a wall system may be comparable to that of the foil in the Reflectix system (CCMC 12342).

Building Practice Notes

Between 1976 and 1986 the National Research Council of Canada issued a series of notes that presented observations, explanations and guidelines on a wide variety of everyday building issues and concerns. Although the series has been discontinued for a long time, much of the information remains relevant today. Copies of the notes (in Adobe .pdf format) available from the NRC web site: *http://irc.nrc-cnrc.gc.ca/pubs/bpn/index_e.html*

No. 1 Not available
No. 2 A Survey of Some Problems with Brick Masonry Buildings (1976, 3.52mb)
No. 3 Adding Insulation to House Attics (1976, 655kb)
No. 4 The Effect of Increased Insulation on Exposed Bituminous Roofing Membranes (1977, 1.01mb)
No. 5 Quality Control in Preparing Masonry Mortar (1977, 1.27mb)
No. 6 Energy Conservation and Roofs (1977, 3.55mb)
No. 7 Damage to Brick and Stone Veneer on Tall Buildings (1978, 332kb)
No. 8 The Use of Vapour Barriers Under Concrete Slabs on Ground (1978, 622kb)
No. 9 Fire Detectors for the Home (1978, 1.53mb)
No. 10 How Dry is your Basement Floor? (1978, 637kb)
No. 11 Not available
No. 12 Rain Penetration and Masonry Wall Systems (1979, 934kb)
No. 13 Rain Penetration and Design Detail for Masonry Walls (1979, 1.6mb)
No. 14 Accessible Pedestrian Systems For Those With Physical Disabilities (1979, 7.51mb)
No. 15 Building Your Own House: Some Useful Tips (1979, 2.56mb)
No. 16 Workmanship and Rain Penetration of Masonry Walls (1980, 1.27mb)
No. 17 Insulated Window Shutters (1980, 699kb)
No. 18 Wind Loads on Low Buildings (1981, 1.49mb)
No. 19 Not available
No. 20 Estimating Energy Savings from Reinsulating Houses (1981, 5.24mb)
No. 21 Insulation Retrofitting : A Case History (1981, 2.91mb)
No. 22 Termites and Carpenter Ants (1981, 5.16mb)
No. 23 Not available
No. 24 Performance of Add-On Heat Pumps in Various Parts of Canada (1981, 1.37mb)
No. 25 The Soundproof Basement (1981, 1.31mb)
No. 26 Estimating Temperature Gradients and Dew Point Temperatures for Building Envelopes (1982, 4.37mb)
No. 27 Mark XI Energy Research Project : Summary of Results, 1978-1981 (1982, 2.91mb)
No. 28 Factors Affecting Efficiency in the Production of Architectural Drawings (1982, 3.04mb)
No. 29 Building Drawings Checklist : Architectural Drawings (1982, 3.33mb)
No. 30 Design and Construction of Low Energy Houses in Saskatchewan (1982, 1.34mb)
No. 31 Thermal Envelope Houses (1982, 1.41mb)
No. 32 A Study of the Construction Process (1982, 946kb)
No. 33 Not available
No. 34 Improvement of Airtightness in Four Schools (1982, 1.06mb)
No. 35 Recommendations for Improving the Safety of Stairs (1982, 2.89mb)
No. 36 Not available
No. 37 Building Envelope Design Using Metal and Glass Curtain Wall Systems (1982, 2.92mb)
No. 38 Low Energy Prairie Housing: A Survey of Some Essential Features (1982, 1.55mb)
No. 39 Building Drawings Checklist: Structural Drawings for Housing (1982, 2.51mb)
No. 40 Building Drawings Checklist : Mechanical Drawings for Housing (1982, 3.43mb)
No. 41 Building Drawings Checklist : Electrical Drawings for Housing (1983, 2.57mb)
No. 42 Rain Leakage of Residential Windows in the Lower Mainland of British Columbia (1984, 1.33mb)
No. 43 Not available
No. 44 How to Reduce Noise Transmission Between Homes (Apartments) (1983, 2.27mb)
No. 45 Not available
No. 46 Building Drawings Checklist: Landscape Drawings (1984, 3.48mb)
No. 47 Surveying an Older House: Inspection Checklist (1984, 1.95mb)
No. 48 Stair Calculator (1984, 565kb)
No. 49 Field Visits to Moisture Troubled Housing in a Maritime Climate (1984, 1.7mb)
No. 50 New Roofing Materials (1984, 3.19mb)
No. 51 Installation Practice and Reliability of Add-On Heat Pumps (1985, 1.92mb)
No. 52 The Principles and Dilemmas of Designing Durable House Envelopes for the North (1985, 5.65mb)
No. 53 Accessibility Requirements in the National Building Code of Canada 1985 (1985, 1.15mb)
No. 54 The Difference Between a Vapour Barrier and an Air Barrier (1985, 3.04mb)
No. 55 Energy Considerations in the Design of Northern Housing (1985, 2.2mb)
No. 56 Controlling Sound Transmission into Buildings (1985, 1.87mb)
No. 57 The Ventilation of Insulated Roofs (1985, 935kb)
No. 58 Benchmark Procedure to Evaluate Computer-Aided Design and Drafting Systems for Building Industry Applications (1985, 1.12mb)
No. 59 Conformance to Barrier-Free Design Criteria : Accessibility Compliance Checklist for Office Buildings (1985, 967kb)
No. 60 Not available
No. 61 Shear Resistance of Wood Frame Walls (1985, 813kb)
No. 62 Guide to the Most Effective Locations for Smoke Detectors in Residential Buildings (1986, 486kb)

Indoor Air Quality and Housing Durability Courses

IAQ Resources Canada will be offering their indoor air quality and housing durability workshop series in Vancouver, Kelowna, Nanaimo, and Victoria, BC and in Markham, ON.

The workshop series will help housing practitioners to improve their decision-making and on-the-job skills. The sessions will be of interest to renovators; builders; housing inspectors and building officials; property and housing managers; HVAC professionals; home maintenance and repair practitioners; public health professionals; real estate and insurance professionals; and other housing practitioners.

Each session offers practical approaches and resources that can be used immediately. The sessions can be taken individually or as a series.

Resolving IAQ and Housing Durability Concerns: The Essentials looks at causes of and solutions for indoor air quality and housing durability concerns. Visual case studies are used to explain basic building science (how a house "works" as a system), pollutant sources (e.g., building materials, house operation issues, mechanical system deficiencies), health issues, moisture, mould and other biological or chemical problems.

Investigating IAQ and Housing Durability Concerns: An Efficient Method demonstrates practical tools, techniques and checklists to perform a simplified, systematic, building science-based investigation to identify IAQ and housing durability concerns. Through visual case studies and small group sessions, participants will learn how to conduct a brief, effective investigation, consider their observations and create an action plan for the client.

Mould Assessment and Clean-Up: Residential, The Essentials focuses on breaking down the process of assessing and cleaning up residential mould contamination into 13 manageable tasks.

Session dates are:

Feb. 15-17, 2006	Vancouver, BC
Feb. 20-22, 2006	Kelowna, BC
March 1-3, 2006	Nanaimo, BC
March 6-8, 2006	Victoria, BC
April 25-27, 2006	Markham, ON

More details:
IAQ Resources Canada
www.iaqresourcescanada.com
Tel. (613) 756-5651
Fax. (613) 756-5564

Wheatboard Production Ceases

Dow Chemical Canada Inc. has announced that Dow BioProducts, a division of Dow Canada, will no longer operate and will cease manufacturing operations of Woodstalk™ brand products from its plant in Elie, Manitoba by December 31, 2005.

In June 2001, Dow BioProducts was created through the acquisition of a majority of the assets of Isobord Enterprises and produced WOODSTALK, a more environmentally-friendly, high quality alternative to wood-based medium density fiberboard (MDF) and particle board, using straw as the principal ingredient.

While Dow BioProducts refined the manufacturing process and improved the quality of the product over the past five years, the demand for a high-quality, low VOC fiberboard product did not develop enough to generate the returns necessary to sustain the business. This, coupled with higher operating costs due to increased natural gas and oil prices made it difficult for Dow to justify continued operation of the business and the plant. ☼

Energy Answers

Rob Dumont

What would be the very best window for a south orientation for passive solar heating in the southern parts of Canada?

To my knowledge, no manufacturer makes such a window, but below is the window that I would choose if money were no object and a manufacturer would assemble it. The window is also assumed to have good visual properties. (An aerogel sandwiched between two sheets of glass fibre would not be visually acceptable.)

With a south-facing window optimized for passive solar gain, you want to maximize the solar gain while minimizing the heat losses.

There are many parts to an outstanding window. Here's my choice for the very best:

1. Glazing

The glass would be low-iron to ensure high transmittance of solar radiation. (Conventional glass when viewed from the edge has a green tint to it because of iron impurities.) Each glass layer would also have an anti-reflection coating facing the outside to minimize reflection of the sun's rays and improve transmittance. Some eyeglasses and camera lenses use anti-reflection coatings.

2. Multiple glazing layers

The window would likely have three glazing layers, although 2 layers might be optimum in the warmer parts of southern Canada.

3. Low emissivity coatings

The purpose of the low-e coatings is to reflect lower temperature long-wave radiation back toward the warm side of the window. A good low-e coating has high transmittance to the higher temperature shorter wave solar radiation.

4. Heavy gas fill.

Krypton gas is the most practical available gas at present for the very best window, but argon is used more frequently because of lower cost. Argon, however, does not have as high a molecular weight as krypton. Krypton has the performance edge.

5. Low conductivity spacer bar

Most conventional windows use an aluminum spacer bar to keep the panes separate. A non-metallic spacer bar with an excellent air and vapour seal would be my choice.

6. Low conductivity frame

A non-metallic material would be my choice. Glass fibre extruded sections filled with polyurethane would likely be my pick.

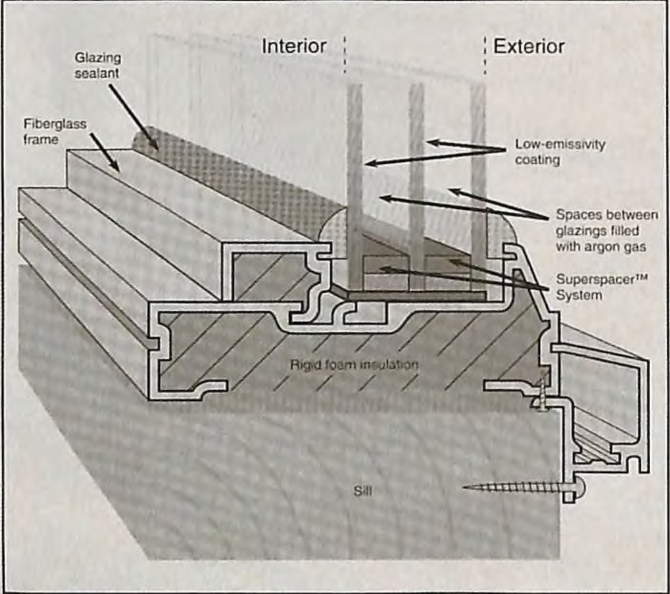
7. Modest frame dimensions

The narrower the frame size, the greater the amount of solar radiation that can enter the window.

8. Operable Windows

If operable, the window should have excellent air tightness characteristics.

The attached figure shows a window that has a number of the above characteristics. The graphic is from the Saskatchewan Advanced House booklet produced by Sunridge Residential.



For non-south window orientations, what would be the very best choice?

For the non-south windows, I would opt for a window that had the smallest heat loss. The winter solar gains on east, west, and north windows are modest compared with the south window gains. A high R-value window would be my choice.

My selection would be a quadruple glazed unit with three low-e coatings, krypton gas fill, low conductivity spacer bar and low conductivity frame.

And if money were ***truly*** no object, I would put two quadruple glazing units in series, and vent the space between the two units to the outside.

What are some heat transfer properties for commercially available windows?

The two heat transfer properties of greatest interest are the Solar Heat Gain Coefficient (SHGC) and the overall window R-value. The values shown in the table below are for the entire window including both the glass and the frame. Also very important is the air leakage value for the window, but it assumed that this will be very low.

The following table is from the ASHRAE Handbook of Fundamentals (Chapter 31, Tables 4 and 13, 2005 Edition.) Generic SHGC and R-values are presented for various types of vertical windows with solar radiation at normal incidence with insulated fiberglass or vinyl frames, with a half-inch space between panes, and a fixed window (non-opening) type. The panes of glass are assumed to be 1/8 inch (3 mm) thick using clear glass with and without low-e coatings. R-values are quoted for winter, nighttime heat losses.

There is a tradeoff, in that going for a high SHGC such as an uncoated doubleglazing yields a relatively high 0.76, but the R-value is not very high at 2.08. At the other extreme, a window with a low SHGC (quadruple glazed SHGC = 0.26) can have a much higher R-value of 5.26.

For the south windows, assuming we have chosen a window design with good spacers and frame material, there are several options that could be chosen: double glazed with low-e and argon, triple glazed with one low-e coated pane and argon, triple glazed with two low-e coated panes and argon. The double glazed unit has the advantage of the higher solar heat gain; the triple low-e argon unit has the advantage of a higher R-value. With the triple low-e the SHGC is 0.41 vs. 0.65 for the double glazed unit with one low-e coating. This triple would admit only about 0.41/0.65 times or 0.63 times as much solar heat gain, and would thus have fewer problems with overheating.

Generic Window Properties

Windows are arranged in descending order of Solar Heat Gain Coefficients

	Solar Heat Gain Coefficient	R Value (h-ft²-°F/BTU)
Single glazing, uncoated	0.90	1.06
Double glazing, uncoated, air	0.76	2.08
Triple glazing, uncoated, air	0.68	2.94
Double glazing, low-e = 0.1, argon	0.65	2.85
Triple glazing, two low--e =0.1, air	0.41	4.00
Triple glazing, two low-e=0.1, argon	0.41	4.35
Quadruple glazing, two low-e =0.1, argon	0.26*	5.26
Quadruple glazing, two low e-=0.1, krypton	0.26*	5.26

* Estimated from the table in the ASHRAE Handbook of Fundamentals, Ch 31, Table 13, 2005

** Quadruple glazing with krypton is assumed to have 1/4 inch spaces between the panes.

*** To convert R-values to metric quantities, divide the values in the above table by 5.678.

**** For best winter performance, the low-e coatings should be positioned to yield a higher SHGC coefficient. Thus on a double glazed window, the low- e coating should be on the surface 3, where surface 1 is on the outside of the outside pane, surface 2 is on the inside of the outside pane. Surface 3 is on the outside of the inner pane.

For the **non-south** windows, the quad glazing would be the best, given that solar gains are low on these orientations.

I don't have any definitive information about the advantages of going to low-iron glass, but I would expect that the SHGC would increase a few percentage points with that type of glass. ☼

NRC·CNRC

NRC-IRC Guidelines for Basements Released

By Mike Swinton and John Burrows

Though they can be subject to greater structural, water and moisture loads than the above-grade portions of a house, basements are often underrated or overlooked in terms of their construction. In fact, the basement is an integral part of many North American homes. Today, consumers in Canada expect basements to provide livable space of the same quality as the rest of the dwelling.

Given the diversity of soil and climatic conditions faced by builders across Canada, it is not always easy to achieve successful basement construction. Problems can occur if constructions are not well understood and not well suited to particular local conditions, as evidenced by the incidence of claims under new home warranty programs.

Within the spectrum of site conditions across the country, builders can come across ideal situations for building basements. For example, there can be large lot sizes and natural slopes that allow surface drainage away from the house in all directions; local soils can be free draining and stable; the water table can be well below the footings; and the local climate can be relatively dry most of the time. In such conditions a very basic basement configuration meeting minimum code requirements can perform adequately. Nevertheless, it is improbable that all of those favourable conditions exist at every construction site. When the builder encounters challenging conditions in a given location, consideration should be given to additional measures that may be needed beyond the code minimum to meet those challenges.

In order to provide better guidance and more options for builders in this regard, the NRC Institute for Research in Construction undertook a major study of basement design and construction in the late 1990s. This work culminated in the development and recent release of a comprehensive document, Performance Guidelines for Basement Envelope Systems and Materials.

Mike Swinton is a group leader in the Building Envelope and Structure Program of the NRC Institute for Research in Construction. He is also research manager of the Canadian Centre for Housing Technology. John Burrows is a freelance technical writer in Ottawa.

Study Objective and General Findings

The objective of the study was to develop design principles to assist in the development and specification of basement envelope and material systems that perform better and last longer for the broad range of Canadian climates, soil conditions and indoor environments. This was achieved by reviewing the performance requirements of the basement envelope and its related systems, reviewing the performance capabilities of available constructions systems, and finally, sorting out the host of regulatory requirements that must be met by the building materials and systems.

The Guidelines record the technical rationale for specifying particular basement envelope materials and systems based on the best information available today. In so doing, they provide a communication link between materials manufacturers and designers, specifiers, builders and their sub-contractors involved in the construction of residential basements. Some of the major findings can be summarized as follows:

♦ Performance expectations for environmental separation have become higher as basements have been used more and more as living space. The notion of classifying basements by their intended use and function is introduced to help designers identify which basement envelope functions need to be stressed to achieve the intended use of the basement. As well, once the class of basement is identified, a consumer can understand the intent of original design. This manages consumer expectations and permits better basements to be valued properly. For instance, "Class A"' basements are intended to be finished livable spaces, and all of the functions of the envelope need to be addressed well. A "Class E" basement is a purely structural foundation with essentially no environmental separation. Both can meet code, but the intended use defines the functional requirements, and the consumer can then understand how much was planned into the basement envelope to achieve its intended use.

♦ The National Building Code of Canada and applicable provincial codes cannot possibly cover all the variations in conditions for basements. This leaves considerable decision-making responsibility to the designer or builder. The Guidelines advocate that designers and builders carefully consider material and equipment selection within the context of the actual site and environmental exposure conditions where the basement will be constructed, and in conjunction with its intended use and occupancy. In most cases, exceeding minimum code requirements will be necessary to achieve acceptable levels of performance corresponding to modern consumer expectations, especially for "Class A" finished basements.

♦ Basement envelopes featuring multiple materials must generally be specified to make sure that all of the functional requirements expected are covered by at least one of those materials or system of materials, and that all of the materials are working together as a system.

♦ Designers and builders need to understand the intended roles of the materials and systems to ensure assembly techniques don't defeat the materials' and systems' intended properties or function.

♦ There are many different approaches to building a basement envelope and more are emerging every year. Some may be more appropriate than others to achieve the intended performance at the lowest feasible cost to the consumer.

♦ There is a balance to be achieved between first cost, cost of repair (including warranty work), and cost of maintenance and operation. That balance changes with conditions. The Guidelines propose approaches for achieving a good balance.

The Guidelines

The Guidelines are organized as follows:

Part 1 – Performance Requirements for Basements – defines the general expectations of basement function and performance, and introduces the concept of "Basement Class" as a means of identifying the intended use of the basement. This part also includes the technical performance requirements – the structural requirements, the environmental separation functions, and the qualitative properties of the envelope system such as buildability and durability.

Part 2 – Basement Envelope System Selection – reviews the basement envelope systems that can be selected to address the performance requirements. Environmental conditions (inside and out) and occupant expectations, combined with the selected envelope system, determines the performance requirements of the materials to be used within the construction system.

Part 3 – Selection of Materials and Equipment for the Basement System – identifies the roles of the materials within the envelope system and indicates what performance characteristics have to be met by those materials for their given roles.

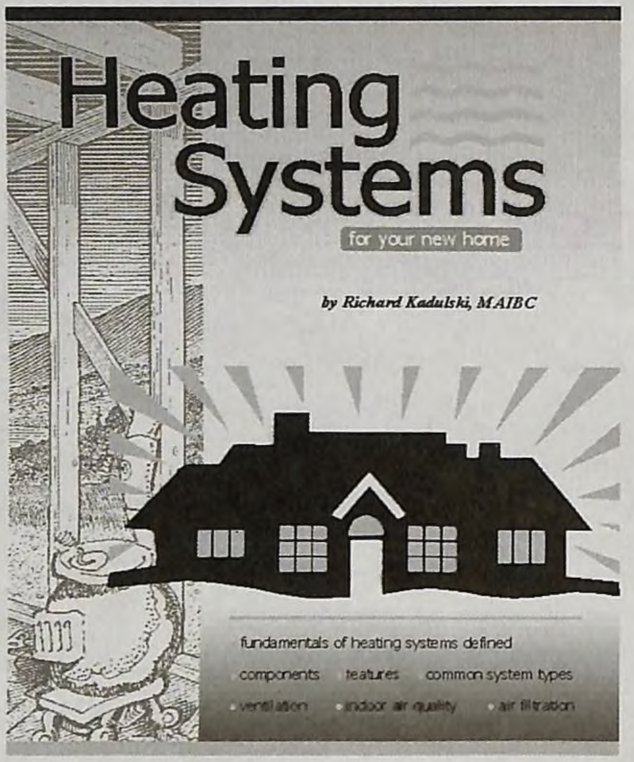
Part 4 – Critical Design Details – addresses some key detailing issues such as the wall-soil interface and window well detailing.

Part 5 – Quality Assurance – reviews various quality control tools available to the Canadian construction industry.

Part 6 – Basement System Cost/Benefit Analysis – introduces the concept of cost/benefit analysis as a planning tool for achieving a balance between long-term basement performance and first cost, for a range of scenarios and locations.

The Guidelines were developed under the guidance of a Steering Committee composed of industry associations and government agency representatives. This committee oversaw the development of the Guidelines and ensured that they reflect the best collective knowledge of Canadian industry and related public and private agencies. The NRC Institute for Research in Construction wishes to thank all those who contributed to the project.

The complete report, Performance Guidelines for Basement Envelope Systems and Materials, has been released and is available at no cost at: *http://irc.nrc-cnrc.gc.ca/pubs/rr/rr199/index_e.html*



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